

OCT 05 2006

## IN THE SPECIFICATION:

Replace the paragraph spanning pages 4 and 5 with the following:

In a preferred embodiment of the invention, Pt is deposited using 2(4-chlorosulfonylphenyl) ethyl trichlorosilane and platinum chloride. The MWCNT/carbon paper composite was immersed in a solution containing 0.04M  $\text{PtCl}_2$ , 1 vol % silane derivative and 6 vol % water in ethanol. The composite structure was then dried at room temperature and reduced in a stream of  $\text{H}_2 + \text{Ar}$  at 550 - 600°C and preferably 580°C for 15 minutes. The 30 minute methanol pretreatment of the MWCNTs/carbon paper composite described in the earlier published application was also used with success to improve the distribution of the Pt on the nanotubes.

Replace the paragraph spanning pages 7 and 8 of the description with the following:

MWCNTs were synthesized on carbon paper at approximately 800°C from the decomposition of ethylene on Co-Ni catalyst particles that were dispersed by a silane intermediate layer adsorbed onto the carbon fibers. Prior to depositing PtRu clusters on the carbon nanotube and carbon fiber composite, different pretreatments of the composite were effected to anchor the bimetallic particles to the tubes. The pretreatment includes (i) methanol immersion for 30 min, (ii) silane pyrolysis at 800°C under  $\text{H}_2 + \text{Ar}$  for 10 min or ((,)) (iii) immersion in concentrated  $\text{H}_2\text{SO}_4 + \text{HNO}_3$  (50:50 vol) at 140°C for 5 min or (iv) treatment with 70% nitric acid for 2 to 20 hours. Pretreatments (ii) and (iii) give a larger density of Pt-Ru alloy nanoparticles than pretreatment (i).

Replace the first complete paragraph on page 8 with the following:

PtRu alloy was deposited on a MWCNT/carbon paper composite by immersing the composite for 2 hours in a solution containing 0.04 M  $\text{PtCl}_2$ , 0.04 M  $\text{RuCl}_2$ , 1 vol% of sulfonated silane, 6 vol % water and ethanol. The concentration of the chloride(s) is sufficient to give a concentration of at least one of Pt and Ru of 0.2 to 2M. The composite was then dried at room temperature and reduced in a flow of  $\text{H}_2$  + Ar at 580°C for 15 min before examination by HRTEM. Figure 5 is a typical HRTEM image showing deposits of PtRu particles. The tube has an outer diameter of nearly 25 nm with a hollow (inner diameter) of about 13 nm. The walls of the tube consist of about 15 cylindrical graphene layers. Nanoparticles are clearly seen to decorate the MWCNTs and they are evenly distributed over the walls of the tubes. The particles are located only on the external surfaces of the tubes, because the tubes were not opened by the pretreatments, even the short immersion in concentrated  $\text{H}_2\text{SO}_4$  +  $\text{HNO}_3$ . The particle size distribution is quite narrow, with an average size of less than 1.5 nm.

The amended paragraphs of the description are set out below.

The paragraph spanning pages 4 and 5 of the description now reads as follows:

In a preferred embodiment of the invention, Pt is deposited using 2(4-chlorosulfonylphenyl) ethyl trichlorosilane and platinum chloride. The MWCNT/carbon paper composite was immersed in a solution containing 0.04M  $\text{PtCl}_2$ , 1 vol % silane derivative and 6 vol % water in ethanol. The composite structure was then dried at room temperature and reduced in a stream of  $\text{H}_2 + \text{Ar}$  at 550 - 600°C and preferably 580°C for 15 minutes. The 30 minute methanol pretreatment of the MWCNTs/carbon paper composite described in the earlier published application was also used with success to improve the distribution of the Pt on the nanotubes.

The paragraph spanning pages 7 and 8 of the description now reads as follows:

MWCNTs were synthesized on carbon paper at approximately 800°C from the decomposition of ethylene on Co-Ni catalyst particles that were dispersed by a silane intermediate layer adsorbed onto the carbon fibers. Prior to depositing PtRu clusters on the carbon nanotube and carbon fiber composite, different pretreatments of the composite were effected to anchor the bimetallic particles to the tubes. The pretreatment includes (i) methanol immersion for 30 min, (ii) silane pyrolysis at 800°C under  $\text{H}_2 + \text{Ar}$  for 10 min, (iii) Immersion in concentrated  $\text{H}_2\text{SO}_4 + \text{HNO}_3$  (50:50 vol) at 140°C for 5 min or (iv) treatment with 70% nitric acid for 2 to 20 hours.

Pretreatments (ii) and (iii) give a larger density of Pt-Ru alloy nanoparticles than pretreatment (i).

The first complete paragraph on page 8 now reads as follows:

PtRu alloy was deposited on a MWCNT/carbon paper composite by immersing the composite for 2 hours in a solution containing 0.04 M  $\text{PtCl}_2$ , 0.04 M  $\text{RuCl}_2$ , 1 vol% of sulfonated silane, 6 vol % water and ethanol. The concentration of the chloride(s) is sufficient to give a concentration of at least one of Pt and Ru of 0.2 to 2M. The composite was then dried at room temperature and reduced in a flow of  $\text{H}_2 + \text{Ar}$  at  $580^\circ\text{C}$  for 15 min before examination by HRTEM. Figure 5 is a typical HRTEM image showing deposits of PtRu particles. The tube has an outer diameter of nearly 25 nm with a hollow (inner diameter) of about 13 nm. The walls of the tube consist of about 15 cylindrical graphene layers. Nanoparticles are clearly seen to decorate the MWCNTs and they are evenly distributed over the walls of the tubes. The particles are located only on the external surfaces of the tubes, because the tubes were not opened by the pretreatments, even the short immersion in concentrated  $\text{H}_2\text{SO}_4 + \text{HNO}_3$ . The particle size distribution is quite narrow, with an average size of less than 1.5 nm.

ethyl trichlorosilane and 6 volume percent water in ethanol.

14. (original) The process of claim 13, wherein the composite structure is reduced at a temperature of 550 to 600°C in a hydrogen-argon atmosphere.

15. (original) The process of claim 14, wherein reduction of the composite structure is effected by heating the structure at 580°C in a stream of H<sub>2</sub>-Ar for 15 minutes.

16. (original) A process for producing carbon nanotubes with platinum particles thereon comprising the steps of:

- (a) preparing a silane solution of 2(4-chlorosulfonylphenyl) ethyl trichlorosilane and platinum chloride;
- (b) immersing a carbon fiber substrate carrying multiwalled carbon nanotubes in the silane solution to yield a composite structure of carbon fiber substrate, carbon nanotubes and platinum particles; and
- (c) reducing the composite structure to yield a composite of carbon fiber substrate, multiwalled carbon nanotubes and platinum particles on the nanotubes.

17. (original) The process of claim 16, wherein carbon fiber substrate carrying the carbon nanotubes is immersed in methanol before immersion in the silane solution.

18. (original) The process of claim 11, wherein the silane solution is a solution of 0.04 M RuCl<sub>2</sub>, 1 volume percent 2(4-chlorosulfonylphenyl) ethyl trichlorosilane and 6 volume percent water in ethanol.

19. (original) A process for producing carbon nanotubes with platinum/ruthenium alloy particles thereon comprising the steps of:

- (a) preparing a silane solution of 2-(4-chlorosulfonylphenyl) ethyl trichlorosilane, platinum chloride and ruthenium chloride;
- (b) immersing a carbon fiber substrate carrying multiwalled carbon nanotubes in the silane solution to yield a composite structure of carbon fiber substrate, carbon nanotubes and platinum/ruthenium alloy particles; and
- (c) reducing the composite structure to yield a composite of carbon fiber substrate, multiwalled carbon nanotubes and platinum/ruthenium alloy particles on the nanotubes.

20. (original) The process of claim 19, wherein the silane solution contains 0.04M  $\text{PtCl}_2$ , 0.04M  $\text{RuCl}_2$ , 1 vol % 2-(4-chlorosulfonylphenyl) ethyl trichlorosilane, and 6 vol % water and the remainder ethanol.

21. (original) The process of claim 19, wherein the substrate carrying the carbon nanotubes is pretreated by one of (i) methanol immersion, (ii) silane pyrolysis in an  $\text{H}_2$  and Ar atmosphere and (iii) Immersion in concentrated 50:50  $\text{H}_2\text{SO}_4 + \text{HNO}_3$  before immersion in the silane solution.

22. (new) A process for producing carbon nanotubes with metal catalyst particles thereon comprising the steps of:

- (a) preparing a 2(4-chlorosulfonylphenyl) ethyl trichlorosilane solution of a metal catalyst, wherein the metal catalyst is at least one of platinum and ruthenium;
- (b) immersing an electrically conducting substrate carrying carbon nanotubes in the silane solution, the silane solution containing at least one of a platinum and a ruthenium salt to yield a composite structure of

OCT 05 2006

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